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(54) **Smart laser diode array assembly**

Intelligente Laserdiodenanordnung

Arrangement de diodes laser intelligentes

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FIELD OF THE INVENTION

[0001] The present invention relates generally to lasers diodes and, in particular, to an assembly that includes a laser diode array, an integral memory device storing operational information about the laser diode array, and an integral processing device that records information to and retrieves information from the memory device.

BACKGROUND OF THE INVENTION

[0002] Semiconductor laser diodes have numerous advantages. They are small in that the widths of their active regions are typically submicron to a few microns and their heights are usually no more than a fraction of a millimeter. The length of their active regions is typically less than about a millimeter. The internal reflective surfaces, which are required in order to produce emission in one direction, are formed by cleaving the substrate from which the laser diodes are produced and, thus, have high mechanical stability. Additionally, high efficiencies are possible with semiconductor laser diodes with pulsed junction laser diodes having external quantum efficiencies near 50% in some cases.

[0003] The cost and packaging of laser diodes are problems that has limited their commercialization. It is only recently that both the technology and availability of laser diode bars, and a method for packaging them, has made two dimensional laser diode pump arrays a commercial reality. One technique for producing such a two dimensional laser diode array is demonstrated in the U. S. Patents Nos. 5,040,187 and 5,128,951 to Karpinski. Also, newer techniques have been used to make more efficient an older packaging approach whereby individual diodes are sandwiched between two metallic foils. The advent of lower cost laser diodes and efficient packaging has led to the possibility of producing very large, solid-state laser systems which use many pump arrays.

[0004] While laser diode pump arrays have a relatively long life when compared to the traditional flash-lamp or arc-lamp pump sources, they are still considered consumable items that require periodic replacement. In some cases with modularized laser diode arrays, one may even wish to replace only a portion of the array. For pulsed lasers, the number of shots which the laser diode arrays have fired is recorded. For continuous-wave (CW) lasers, the amount of time the laser diode arrays have operated (time-on) is of interest. Typically, these values are monitored and stored within the external electronic control systems which operate these laser systems. These electronic control systems must contain a shot-counter or time-on counter for each laser diode pump array to determine the relative age of each laser diode array thereby permitting the development of a replacement schedule for each laser diode array. However, when a laser diode pump array is replaced, these shot-counters or on-timers must have the ability to be reset to zero if a new laser diode array is used. If a used laser diode array is installed, then these shot-counters or on-timers must have the ability to be reset to a predetermined value. Furthermore, when a laser diode array is removed from a system for replacement, a difficulty arises in that there is no longer a shot count or on-time associated with the pump array, unless written records are meticulously kept.

[0005] In addition to the shot-count, there is other information about a diode array that is of particular interest, such as the serial number of the array, the number and frequency of over-temperature fault conditions, and the voltage drop (i.e. the resistance rise) across the array. These characteristics are useful for selecting an application for a used laser diode array, or for determining the causes of its failure. These characteristics are also important for warranty purposes. However, the operator of the system has no interest in recording these data since it may limit his or her ability to rely on the warranty when a failure arises. On the other hand, the manufacturer has a keen interest in knowing the operational history of an array for warranty purposes.

[0006] When semiconductor laser diodes are used as the optical pumping source for larger, solid-state laser systems, the emitted wavelength is critical. Laser diode pump arrays achieve efficient pumping of the laser host material (e.g. Neodymium-doped, Yttrium-Aluminum Garnet) by emitting all of their light energy in a very narrow spectral band which is matched to the absorption spectrum of the gain media (i.e. slabs, rods, crystals etc.), typically within 2-6 nanometers full-width at the half-maximum point (fwhm). The laser diode pump array emission wavelength is a function of the temperature at which the pump array is operated. The pump array temperature is a complicated function of many interrelated variables. The most important of these variables are the temperature of the coolant flowing to the diode array, the operational parameters of the diode array, and the configuration of the heat exchanger on which the laser diodes are mounted. The operational parameter of a CW driven array is simply the drive current. But for pulsed laser systems, the peak drive current, the repetition rate, and the pulse width of the drive current are all important operational parameters. Because the performance of the laser diode array changes during the service life of a laser diode array, the host external system controller has to compensate for any degradation of performance (output power or wavelength) by modifying these input operational parameters except for the heat exchanger configuration. Often, the altering of the operational parameters requires manual calibration of the arrays using external optical sensors. This is a tedious job and requires a skilled technician who understands the ramifications of modifying the interrelated variables which change the output power and wavelength. Even when the laser diode array's operational

parameters are properly calibrated, rapid changes in the performance of the laser diode array may go unnoticed until the next scheduled maintenance. This manual calibration also is often required during the initial installation of the laser diode array assembly.

[0007] Therefore, a need exists for a laser diode array assembly that includes an integral means for recording operational events and maintaining this information with the assembly throughout its service life. It would also be beneficial for this laser diode array assembly to have the capability of instructing the external laser operating system on the input drive parameters that should be used to provide for optimal output of the laser diode array assembly.

[0008] EP 512541 describes a system that maintains a specified light quantity from the laser device so as to scan bar codes. The system compares the actual drive current with the initial drive current at particular temperature that is stored in a memory unit 24, presumably as this certain specified light quantity is being emitted from the laser device. If the actual drive current required to obtain the specified light quantity is a predetermined percentage larger than the initial drive current, then a warning unit generates an alarm to indicate the laser device is near the end of its service life.

[0009] U.S. Patent No. 5504762 describes a fiber optic laser system that utilizes the stray light produced from the coupling optics as the feedback mechanism, as opposed to using the actual emitted light from the laser source.

SUMMARY OF THE INVENTION

[0010] The present invention is defined in claim 1 and claim 23.

[0011] A modular laser diode array assembly includes at least one laser diode array, an intermediate structure on which the array is mounted, and an integral memory device. The laser diode array has a plurality of laser diodes which are in electrical contact with at least one other of the plurality of laser diodes. The assembly further includes means for supplying external power to the laser diode array. The memory device stores operating information for the laser diode array and is mounted on the intermediate structure which may be a printed circuit board. The memory device communicates with an external operating system. After the assembly is installed in and connected to the external operating system, a system controller accesses the memory device to obtain the operating information (temperature, input power parameters, etc.) which enables the system controller to properly apply power to, or set conditions for, the laser diode array.

[0012] In another embodiment, the assembly includes sensors for sensing the operating conditions experienced by the laser diode array. The external operating system monitors the sensors to assist in determining the operational parameters at which the system is to be operated. These sensors may be optical power sensors, optical wavelength sensors, electrical input power sensors, temperature sensors, vibration s nsors, etc.

[0013] In yet another embodiment, the assembly includes processing means that communicates with the external operating system. The processing means is coupled to the sensors for directly monitoring the operating conditions of the laser diode array and is also coupled to the memory device. Based on the operating conditions monitored, the processing means instructs the external operating system to supply the optimum operating parameters. Thus, the assembly is self-calibrating in that it monitors the operating conditions and instructs the external operating system to provide input power in a manner that allows for the optimum output.

[0014] Using the integral memory device and the processing means provides numerous benefits. For example, the shot-count or on-time value becomes physically a part of the assembly as it is stored within the integral memory device. This integral memory device could then be read from and updated, as necessary, by the control electronics of the external operating system or the processing means when one is used.

[0015] There are many additional pieces of data which could be stored in this memory device, such as: the array serial number; the number and times of fault conditions such as over temperature or activation of protection circuitry; the voltage drop across the array and the time of the occurrence if it changes significantly (this may be an indication of individual laser bar failures); and the array's spectral and power response to different operational conditions. The memory device may also record the ambient environmental conditions such as the ambient temperature, the ambient shock environment, ambient humidity, or electrostatic discharge (ESD) events resulting from the environment around the array.

[0016] The above summary, as well as the appended claims, are not intended to represent each embodiment or every aspect of the application.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Other objects and advantages of the invention will become apparent upon reading the following detailed description and upon reference to the drawings in which:

FIG. 1A is a perspective view of a laser diode array used in the present invention;

FIG. 1B is a perspective view of another laser diode array used in the present invention;

FIGS. 2A-2D are views of a multiple-array assembly having an integral memory device and a sensor;

FIGS. 3A-3C are views of a multiple-array assembly having an integral processing device including a memory device, a sensor, and multiple photodetectors;

FIGS. 4A-4B are views of a single-array assembly having an integral processing device including a memory device, a sensor, and a photodetector;

FIG. 5 is a plan view of a single-array assembly having an integral memory device, a temperature sensor, and a photodetector;

FIG. 6 is a plan view of a multiple-array assembly having an integral processing device including a memory device, a temperature sensor, multiple photodetectors, and an input power sensing device;

FIG. 7 is perspective view of the multiple-array assembly of FIGS. 3A-3C including a connector and being installed on a heat exchanger;

FIG. 8 is a perspective view of a multiple-array assembly having an printed circuit board positioned at approximately 90 degrees from the plane in which the emitting surfaces reside;

FIG. 9 is a schematic view of a multiple-array assembly incorporating the present invention and being installed in an external operating system; and

FIG. 10 is a schematic view of an external operating system being coupled to multiple assemblies labeled 1-N.

[0018] While the invention is susceptible to various modifications and alternative forms, a specific embodiment thereof has been shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that it is not intended to limit the invention to the particular forms disclosed. Quite to the contrary, the intent is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

[0019] Referring initially to FIG. 1A, a laser diode array 10 is illustrated in a perspective view. The laser diode array 10 includes a plurality of laser diodes packages 12 each of which includes a laser diode 13 sandwiched between a heat sink 14 and a lid 17. The laser diode packages 12 are arranged in a parallel fashion commonly referred to as a stack. At the ends of the stack are endcaps 18 and 19 through which power is supplied to the stack of laser diode packages 12. A thermal backplane 20, usually made of an electrically insulative material, such as beryllium oxide, is the surface to which each of the packages 12 is mounted. The laser diode array 10 is one type of array that can be used in the present invention.

[0020] In FIG. 1B, a second type of laser diode array 30 is illustrated. The laser diode array 30 includes a substrate 32 made of an electrically insulative material and a plurality of grooves 34 which are cut in the substrate 32. Within each groove 34 is a laser diode bar 36. To conduct electricity through the plurality of laser diode bars 36, a metallized layer is placed within each groove 34 and connects adjacent grooves 34. The bottom of the substrate 32 is the backplane through which heat flows to the heat exchanger positioned below the bottom. Although the number of grooves 34 is shown as ten, the application of the array 30 dictates the amount laser diode bars 36 and, therefore, the number of grooves 34. Laser diode array 30 is another type of laser diode array that can be used with the present invention.

[0021] FIGS. 2A-2D are views of an assembly 40 having six laser diode arrays 30, an integral memory device 42, and a sensor 44. The memory device 42 and the sensor 44 are mounted on a printed circuit board (PCB) 46. The information on the memory device 42 can be accessed and the sensor 44 can be monitored through contact pads 47 located on the PCB 46. A board heat sink 48 is disposed on the back of the PCB 46 and is the surface to which the backplanes of the laser diode arrays 30 are attached. The diode arrays 30 can be soldered to this heat sink 48 or fastened in other ways which minimize the thermal resistance across the interface of the heat sink 48 and the laser diode array 30.

[0022] The sensor 44 can be of a type that measures output power or output wavelength (assuming it receives the emitted light). More commonly, the sensor 44 is a temperature sensor since the temperature of the arrays 30 is critical to their operation. If the sensor 44 is a temperature sensor, it could be moved to a location closer to the backplanes of the arrays 30. The sensor 44 may also be an ESD sensor or one that measures the shot-count or on-time of the array 30. Furthermore, the PCB 46 may contain multiple sensors although only one sensor 44 is shown.

[0023] The memory device 42 preferably is a non-volatile memory device such that the information stored therein is not altered when power is removed from the memory device 42. An example of such a memory device 42 is the model 24632, manufactured by Microchip, of Chandler, Arizona.

[0024] To protect the emitting surfaces of the laser diode arrays 30, a protective window 50 can be affixed to the assembly 40. The protective window 50 is supported by a retainer frame 52. The frame 52 and the window 50 may merely act to protect the upper emitting surfaces. Alternatively, the frame 52 and window 50 may completely seal the six laser diode arrays 30 by placing a sealing material between the frame 52 and the window 50. The window 50 can be made of a variety of materials including acrylic with an anti-reflective coating. Besides the window 50 that is shown, the window 50 could be replaced by a diffractive, binary, or two-dimensional array of lenses to provide focusing and collimation to the beam of energy. FIG. 2D illustrates the assembly 40 without the window 50 and retainer frame 52.

[0025] The laser diode arrays 30 require electrical energy to produce the emitted radiation. Thus, a pair of contact pads 54a and 54b are located on the PCB 46. To provide electrical energy to the laser diode arrays 30, a pair of leads 56a and 56b are disposed between the

endcaps of the two end arrays 30 and the pads 54a and 54b. Adjacent arrays 30 are connected in electrical series through jumpers 57. In the case where the window 50 and the frame 52 seal the laser diodes 30, the leads 56a and 56b can be potted or bonded onto the window frame 52. The host external operating system makes electrical contact with the assembly 40 through the contact pads 54a and 54b.

[0026] The PCB 46 and the board heat sink 48 include holes 58 through which fasteners will pass to connect the assembly 40 to the ultimate heat sink which is typically a high efficiency heat exchanger. Also provided are indexing holes 60 which align the PCB 46 and, therefore, the array 30 on the ultimate heat sink.

[0027] Although the PCB 46 is shown as the intermediate structure between the array 30 and the memory device 42, other structures could be used. For example, merely providing an epoxy layer which adheres the memory device 42 to the array 30 may suffice if the epoxy provides electrical insulation.

[0028] The memory device 42 contains the operating information for the laser diode arrays 30. The types of information can range from the basic to the complex. For example, the identity of the laser diode array assembly 40 can be recorded in the memory device. This can include the wafer number of the wafers that were used to produce the laser diode bars that are contained in each array 30. It may also include the lot number of the bars comprising the arrays 30 or the laser diode bar number. It may also include an inspector number associated with the individual who approved of the bar in the quality control department.

[0029] The memory device 42 can also be loaded with performance data on the laser diode array assembly 40. For example, the center wavelength can be given as well as the wavelength shift as a function of temperature (i.e. Gallium Arsenide laser diodes shift at about 1 nanometer per about 3-4°C). The wavelength distribution of the arrays 30 can be stored so as to provide the full-width at half maximum value (FWHM) (i.e. the difference between the wavelengths at the point on the wavelength distribution curve where the intensity is at one-half of its maximum value). This FWHM value is critical when the assembly 40 is used for solid-state laser pumping applications. The wavelength can also be given as a function of spatial orientation along the assembly 40.

[0030] Information related to the output power can be included as well. For example, the output power can be given as a function of the efficiency of the arrays 30, the current and voltage at which the arrays 30 are driven, or the threshold current (i.e. the current after which lasing occurs). The output power can also be given as a function of spatial orientation along the assembly 40. Also, the estimated output power degradation of the array 30 over its service life can be stored.

[0031] The memory device 42 can also include extreme design values for various operating conditions that should not be exceeded for a particular array. For example, the maximum or minimum design operating temperature can be recorded as can the maximum design drive parameters such as current, pulse-width, duty-cycle, voltage, etc. This allows for a real-time comparison between the actual operating conditions and the extreme design conditions to ensure that no damage will occur to the laser diode array 30. The external operating system may use such a comparison to shut-down the system when the extreme design values are exceeded.

[0032] Although the memory device 42 has been described thus far as having operational information that has been recorded before its delivery to the customer, the memory device 42 is also updated with information throughout its service life. Typically, the external operating system is monitoring various environmental conditions including temperature, vibration, shock, humidity, and also the input drive parameters. Since the operating system is configured to read from the memory device 42, the only difference needed to achieve the goal of updating the memory device 42 is merely having an external operating system with the capability to write to the memory device 42. Consequently, the memory device 42 then captures the operational history of the array 30 which is advantageous for determining the cause of failures and for warranty purposes.

[0033] The types of operational information related to the service life of the array 30 that can be recorded in the memory device 42 is quite extensive. For example, the shot-count of a pulsed laser diode array 30 or the on-time of a CW laser diode array 30 can be recorded. This is a very important value when considering the warranty of the array 30.

[0034] The extreme operating conditions which the laser diode array 30 experiences can be recorded in the memory device 42 which is also useful for warranty purposes and for determining the cause for failures. Thus, the maximum and minimum operating temperature can be recorded in the memory device 42. Other operating conditions such as the maximum shock, vibration, and humidity can be recorded as well. The maximum drive parameters (current, voltage, pulse width, frequency, etc.) can also be recorded in the memory device 42. Additionally, the extreme ambient conditions of the environment surrounding the array 30 or surrounding the entire external operating system can be stored as well (nonoperational or operational).

[0035] A list of incident reports may be recorded in the memory device 42. This may include the over-temperature failures, over-current failures, over-voltage failures, reverse-voltage failures (i.e. wrong bias across the arrays 30), coolant-flow interrupts (to the heat exchanger), and electrostatic discharge events. These faults can be recorded as merely an affirmative response to whether the fault occurred or as the value of the condition. Additionally, a drop in the voltage across the array 30 is indicative of a single laser diode failure and may be recorded. For example, a typical voltage drop across one good laser diode is approximately 2.0 volts and about

0.5 volt after certain types of failures. The number of laser diode bar failures can be estimated by such a voltage drop. Other types of fault conditions may be included as well, including those fault conditions recorded by sensors monitoring the output of the arrays 30 (i.e. wavelength and power).

[0036] Thus far, only fault conditions, operating conditions, and non-operating conditions have been discussed as being data that are recorded in the memory device 42. However, recording the dates and times of these conditions is also worthwhile and can be accomplished by having the external operating system write the times that these conditions occur in the memory device 42. When the time values are recorded, the memory device 42 then can be used to store a variety of parameters as a function of time (temperature, input power, output power, output wavelength, etc. v. time).

[0037] FIGS. 3A-3C illustrate an assembly 140 having multiple arrays 30 similar to the assembly 40 of FIGS. 2A-2D. The assembly 140 includes a processor 143 and a temperature sensor 144 that are mounted on a PCB 146. A heat sink 148 is located on the backside of the PCB 146 and is the structure to which the arrays 30 are attached. Each array 30 has a corresponding photodetector 149 which measures the output characteristics of the emitted light. As shown best in FIG. 3C, the emitted light reflects partially off the inside surface of the window 150 and then hits the photodetector 149. The photodetector 149 may measure the power of the reflected light which corresponds to the output power of the entire array 30. Alternatively, the photodetector 149 may be of a more advanced type that measures the output wavelength of the reflected beam which corresponds to the output wavelength of the emitted output.

[0038] The processor 143 as shown includes a memory portion which allows basic information to be stored therein (extreme operating temperatures, input powers, etc.) If a larger amount of information is to be stored, then it may be desirable to include a separate memory chip on the PCB 146, like the memory device 42 in FIG. 2, and couple it to the processor 143 for storing the additional data. This may be required when the operational history of the laser diode array 30 is to be recorded.

[0039] The processor 143 is coupled to the temperature sensor 144 and to the photodetectors 149 through traces on the PCB 146. The processor 143 is also coupled to an external operating system through contact pads 147. In this way, the processor 143 determines the appropriate drive levels to be supplied by the external operating system based on the conditions it monitors through the temperature sensor 144 and the photodetectors 149. The processor 143 also instructs the external operating system to supply the coolant at a temperature and a rate that maintains the temperature of the temperature sensor 144 at the desired value. The processor 143, therefore, provides a self-calibrating system in that any deviations seen in the output power and wavelength can be altered by instructing the operating system to change the input drive parameters and the coolant characteristics.

[0040] The processor 143 would typically be an Application Specific Integrated Circuit (ASIC) or a hybrid, custom-manufactured model.

[0041] FIGS. 4A and 4B illustrate an assembly 180 having a single array 182, a processor 184, a photodetector 186, and a temperature sensor 188. The array 182 holds substantially more bars than arrays 10 and 30 of FIGS. 1A and 1B. The photodetector 186 and the temperature sensor 188 are mounted on a PCB 190 and are coupled to the processor 184 which is also mounted on the PCB 190. The array 182 is mounted to a heat sink 189 below the PCB 190. Power is supplied to the array 182 via a pair of contacts 192 and 194 which are coupled to the array 182 via leads 192a and 194a. A trace 194b runs within the PCB 190 from the lead 194a to the endcap of the array 182 adjacent the photodetector 186.

[0042] The processor 184 has internal memory portion with enough capacity to perform the required tasks. Alternatively, a memory device can be mounted on the PCB 190 and coupled to the processor 184.

[0043] Also connected to the processor 184 is a circuit 196 which limits high power being received by the processor 184. This circuit 196 is coupled to the input power leads and allows the processor 184 to determine the voltage drop across the array 182 or the current therethrough. Because the array 182 is usually coupled in series with a field effect transistor (FET) and a known voltage drop occurs across the diode array 182 and the FET, the processor 184 could also monitor the voltage drop across the FET to determine the voltage drop across the array 182. The change in the voltage drop across the array 182 is indicative of a failure of the individual laser diode bars within the array 182. The circuit 196 may include a fuse for guarding against high voltage or high current.

[0044] The use of such a circuit 196 also permits the counting of each shot supplied to the array 182 or the amount of on-time if array 182 is a CW laser. Thus, the processor 184 would count and store these values.

[0045] Although the circuit 196 has been described as one which measures the voltage drop across the array 182 or counts shots, it could also include a reverse-bias sensor (possibly an electrical diode) that permits the flow of current in one direction. If a voltage is applied in the wrong direction, then the current will flow through the electrical diode instead of the array 182 which decreases the likelihood of any harm to the array. Thus, the processor 184 can monitor the occurrence of a reverse-bias fault.

[0046] The circuit 196 can also include components for monitoring a electrostatic discharge across the array 182. Thus, the processor 184 could monitor this circuit 196 for such an event and record it as well.

[0047] FIG. 5 illustrates an assembly 200 having a single array 202, a memory device 204, a photodetector

206, and a temperature sensor 208. These memory device 204 and the photodetector 206 are mounted on a PCB 210 while the array is mounted on a heat sink on the bottom of the PCB 210. Thus, this single-array assembly 200 does not have the processing capability of assembly 180 in FIG. 4. Instead, assembly 200 supplies to the external operating system the operational information needed to operate the array 202. Also, the memory device 204 can be configured to receive and record information (fault conditions, operating conditions, etc.) from the external operating system.

[0048] The external operating system communicates with the memory device 204 by the contact pads 212 at the edges of the PCB 210. Likewise, the external operating system communicates with the photodetector 206 and the temperature sensor 208 via the pads 212.

[0049] FIG. 5 also illustrates the geometrical configuration of the assembly 200. The emitting surfaces of the laser diode array 202 are within an area defined by LDY multiplied by LDX. The area of the PCB 210 is defined PCBX multiplied by PCBY. It is desirable to keep the ratio of the PCB area to the emitting area as low as possible such that the assembly 200 having these additional components (e.g. sensors, memory devices, processors, etc.) is not much larger that just the array. This is important for retrofitting purposes. Generally, the ratio of the PCB area to the emitting area is less than approximately 10 to 1. In a preferred embodiment, the ratio is in the range from about 5 to 1 to about 7 to 1. When a connector is added to the PCB 210 (see FIGS. 7 and 9 below), the ratio is less than about 14 to 1.

[0050] FIG. 6 illustrates an assembly 230 having six arrays 30 which is very similar to the assembly 140 shown in FIGS 3A-3C. However, the processor 232 is coupled to the contacts 233 and 234 through circuits 236 and 238. These circuits 236 limit the high power to the processor 232 so as to allow the processor 232 to determine the voltage drop across the six arrays 30.

[0051] Again, circuits 236 and 238 may instead, or in addition to what is described above, provide for electrostatic discharge sensing.

[0052] Circuits 236 and 238 may also be used for counting the shots of a pulsed laser or the on-time for a CW laser since the processor 232 can receive a signal from these circuit each time power is supplied to the assembly 230. Alternatively, if circuits 236 include an electromagnetic sensor (e.g. a Hall's Effect sensor) then they just need to be in close proximity to the arrays 30 or the contact pads 233 and 234 such that each time a high-current pulse is supplied to the assembly 200, the Hall's Effect sensor is tripped by the resultant electromagnetic field. The processor 232 then receives the signal after each shot.

[0053] The arrays 30 have a finite life which is in a large part a function of the temperature at which they are operated and the power is supplied thereto. Because the processor 232 monitors both the temperature and the input power, the processor 232 can compare these values to a range of standard, assumed, operating conditions. Then, the processor 232 modifies the estimated life at a predetermined rate programmed in the processor 232 based on the actual conditions under which the arrays 30 are being operated. In a preferred embodiment, not only would the processor 232 inform the external operating system of the amount of service that is remaining, but the processor 232 would also inform the external operating system of the amount that the estimated life has been adjusted based on the actual operating conditions.

[0054] FIG. 7 illustrates an assembly 250, similar to the one shown in FIGS. 2A-2D, that is mounted on a heat exchanger 252 having an inlet port 254 and an outlet port 256. The assembly 250 further includes a connector 258 to which the external operating system is coupled. The arrays 30 are connected to the heat sink 257 of the PCB 259. The heat sink 257 of the PCB 259 is mounted on the heat exchanger 252 by a series of fasteners 260.

[0055] The connector 258 is coupled to a memory device 261, to a sensor 262 (i.e. one of the types discussed thus far), and to power supply contact pads 264 and 266. Each of these devices is mounted on the PCB 259 and is coupled to the connector 258 through traces located on the PCB 259. The connector 258 provides for an easy connection between the assembly 250 and the external operating system.

[0056] FIG. 8 illustrates an alternative embodiment in which an assembly 290 includes a PCB 292 that is located in a plane that is generally perpendicular to the emitting surfaces of arrays 30. Consequently, the arrays 30 are elevated slightly from a base 294 which attaches the assembly 290 to a heat exchanger. Again, the assembly 290 includes a memory device 296 and two sensors 297 and 298. Typically, sensor 298 is a temperature sensor and sensor 297 is a photodetector. Each of the sensors 297 and 298 and the memory device 296 are coupled to contact pads 299 at the end of the PCB 292 through traces (not shown) in the PCB 292. The assembly 290 communicates with the external operating system through these contact pads 299.

[0057] FIG. 9 illustrates the assembly 250 of FIG. 7 installed in the external operating system. Thus, a system controller 300 is coupled to drive electronics 302 which supply the electrical power needed to operate the diode arrays 30. The system controller 300 is also coupled to a chiller 304 which supplies the cooling fluid to the heat exchanger 252 (FIG. 7). The system controller 300 receives operational information from the memory device 261 via the connector 258. For example, the operational information received from the memory device 261 may inform the controller 300 that to obtain X watts of output power at 808 nanometers, the temperature at the temperature sensor 262 must be 31°C and the arrays must be driven at 110 amps with a rate of 30 Hz, and a pulse width of 220 microseconds. The system controller 300 then causes the drive electronics 302 to

supply the requested input power and causes the chiller 304 to provide coolant at a rate and a temperature that will maintain sensor 262 at 31°C.

[0058] Although the cooling system has been described as a chiller 304, the system could also be one which utilizes solid-state thermoelectric coolers such as those manufactured by Marlow Industries of Dallas, Texas. The cooling capacity of these devices varies as a function of the input power. Thus, the system controller 300 would control the electrical power to the thermoelectric coolers such that their cooling capacity would result in the desired temperature at the arrays 30.

[0059] The controller 300 also may store in the memory device 261 operational conditions if the configuration of the memory device 241 allows for this information. Thus, the controller 300 could record to the memory device 261 extreme operating conditions (temperature, humidity, shock, vibration, the amount of on-time or the number of shots, etc.), extreme non-operating conditions (temperature, humidity, shock, vibration), extreme input powers (current, voltage, duty cycle, etc.), and fault conditions (coolant non-flow condition, electrostatic discharge, over-temperature fault, over-power fault, reverse-bias faults). Clearly, sensors (vibration sensors, shock sensors, humidity sensors, etc.) which measure these types of operating conditions would need to be incorporated onto the PCB or be adjacent the assembly 250 and monitored by the controller 300.

[0060] If a processor is used on the assembly 250, then the processor may monitor these sensors instead of the controller 300 monitoring them. Additionally, a processor could monitor the output of the assembly 250 and provide real-time modifications to the instructions sent to the system controller 300. Thus, the basic operating information stored in the memory device 261 would serve as a starting point for operation and be modified based on the conditions sensed by the sensors and monitored by the processor.

[0061] FIG. 10 is a schematic illustrating a concept similar to what is shown in FIG. 9 except that the external operating system 330 is coupled to multiple assemblies 332, 334, 336 to produce the desired output. For example, the desired output from each assembly may by X watts at 808 nanometers. The operating system 330 then receives information from each assembly 332, 334, and 336 through the data interface lines which indicates the temperature and input power require to produce this output. Each assembly 332, 334, and 336 will usually require slightly different operating parameters (e.g. 33°C, 36°C, and 32°C; or 105A, 108A, and 101A) to achieve the desired output. Consequently, the operating system 330 supplies coolant and input power at different levels to each assembly 332, 334, and 336. The operating system 330 may monitor sensors on the assemblies 332, 334, 336 through the sensor lines. Alternatively, if a processor is present on each of the assemblies 332, 334, 336, the processor may monitor the sensors and instruct the operating system 330 accordingly through the data interface lines.

[0062] The present invention is quite useful for numerous reasons. For example, one of the main factors affecting yield and, therefore, the cost of laser diode pump arrays, is selecting only laser diode bars within a small spectral range for incorporation into one array. There is a significant cost savings if it is possible to use pump arrays which have a larger range in their peak emission spectra, since the system control electronics will be able to compensate for the array's spectral differences by using the stored thermal and spectral (wavelength) information. Furthermore, storing the thermal/spectral data within the assembly considerably simplifies replacement of a used or damaged assembly by allowing for the automatic compensation for the new assembly by merely accessing this data within the assembly's memory device. There is no longer the need to build a replacement array that exactly matches the used or damaged array.

[0063] Because the shot count or timer is integral with the assembly, rather than with the external control system electronics, the records are accurately maintained. And, a simplified way of recording significant events (faults, extreme conditions, etc.) is provided. Consequently, the need for meticulously recording this type of information on paper is obviated and, therefore, the integrity of the operational information on the array is greatly improved. Accessing this information from the memory device of the assembly is also useful for later analyzing the problems experience by the assembly.

[0064] The safety features of the assembly are greatly improved by providing in-situ monitoring of such operating conditions such as the array's voltage, temperature, ambient humidity, and the occurrence of fault conditions. This information can be used to shut-down the assembly to avoid damage to the assembly or injury to the operator of the assembly.

[0065] Each of these embodiments and obvious variations thereof is contemplated as falling within the scope of the invention, which is set forth in the following claims.

Claims

1. A modular laser diode array assembly, comprising:

   at least one laser diode array (30) having a plurality of laser diodes (13), each of said plurality of laser diodes for converting electrical energy into optical energy;

   an intermediate structure (46) to which said at least one laser diode array is attached; and

   a memory device (42) mounted on said intermediate structure (46) so as to be integral with said at least one laser diode array, said memory

device (42) for storing operating information for at least one laser diode array, **characterized in that** storing said operating information includes updating of at least one specific operating condition experienced by said at least one laser diode array (30) during operation.

2. The modular laser diode array assembly of claim 1, wherein said operating information includes the serialization identity of said at least one laser diode array.

3. The modular laser diode array assembly of claim 1, wherein said operating information includes an estimate of output energy degradation over the service life of said at least one laser diode array, a wavelength of output energy as a function of temperature of said at least one laser diode array, or output energy of said at least one laser diode array as a function of input power.

4. The modular laser diode array assembly of claims 1-3, wherein said memory device is connected to an external operating system which records in said memory device updated operating information based on the performance of said at least one laser diode array.

5. The modular laser diode array assembly of claims 1-4, wherein said memory device is connected to an external operating system which records in said memory device said specific operating conditions experienced by said at least one laser diode array.

6. The modular laser diode array assembly of claims 1-5, wherein said operating information includes at least one specific operating condition experienced by said at least one laser diode array during operation, said specific operating condition recorded in said memory device include a time of the occurrence of said operating condition.

7. The modular laser diode array assembly of claims 1-6, further including a temperature sensor for providing a temperature of said at least one laser diode array.

8. The modular laser diode array assembly of claim 7, further including means to remove heat from said at least one laser diode array, said heat removal means being operated at a specified level determined by said operating information corresponding to a temperature monitored via said temperature sensor.

9. The modular laser diode array assembly of claims 1-8, further including an optical sensor for providing optical characteristics of said array.

10. The modular laser diode array assembly of claims 1-9, wherein said intermediate structure includes a printed circuit board on which said memory device is mounted, said printed circuit board further having a surface on which said at least one laser diode array is mounted.

11. The modular laser diode array assembly of claim 1, further including:

    at least one sensor for sensing operating conditions experienced by said at least one laser diode array including said specific operating conditions to be stored in said memory device; and

    processing means being mounted on said intermediate structure and being coupled to said at least one sensor for monitoring said operating conditions, said processing means being coupled to said memory device and to an external operating system.

12. The modular laser diode array assembly of claim 11, wherein said memory device is included in said processing means.

13. The modular laser diode array assembly of claims 11-12, wherein said processing means records said at least one specific operating condition sensed by said at least one sensor in said memory device.

14. The modular laser diode array assembly of claims 1-13, wherein said operating information includes at least one specific operating condition experienced by said at least one laser diode array during operation, said at least one specific operating condition includes a maximum temperature of said at least one laser diode array, a maximum power supplied to said at least one laser diode array, a total on-time or shot-count of said at least one laser diode array, or a maximum ambient condition to which said at least one laser diode array is subjected.

15. The modular laser diode array assembly of claims 1-13, wherein said operating information includes at least one specific operating condition experienced by said at least one laser diode array during operation, said at least one specific operating condition includes a fault condition experienced by said at least one laser diode array, said fault condition being one of the group consisting of a reverse-bias fault, a coolant flow fault, an extreme power input fault, an extreme temperature fault, and an electrostatic discharge fault.

16. The modular laser diode array assembly of claim 11, wherein said at least one sensor includes a tem-

perature sensor measuring a temperature of said at least one laser diode array, an optical sensor measuring output energy of said at least one laser diode array, an optical sensor measuring output wavelength of the output energy of said at least one laser diode array, a voltage sensor for measuring the voltage across said at least one laser diode array, or a current sensor positioned between said power contacts pads for measuring the current through said at least one laser diode array.

17. The modular laser diode array assembly of claims 11-16, wherein said processing means instructs said external operating system to drive said at least one laser diode array at a power level delineated by said operating information stored in said memory device.

18. The modular laser diode array assembly of claim 17, wherein said power level is updated based on said operating conditions monitored by said processing means via said at least one sensor.

19. The modular laser diode array assembly of claim 11, further including means to remove heat from said at least one laser diode array and said at least one sensor including a temperature sensor, said processing means controlling said heat removal means at a specified level determined by said operating information corresponding to a temperature monitored via said temperature sensor.

20. The modular laser diode array assembly of claim 11, wherein said intermediate structure includes a printed circuit board on which said memory device and said processing means are mounted, said printed circuit board further having a surface on which said at least one laser diode array is mounted.

21. The modular laser diode array assembly of claims 10 or 20, wherein said printed circuit board includes a connector to which said external operating system is mounted.

22. The modular laser diode array assembly of claims 10 or 20 wherein said at least one laser diode array has an emitting region where energy is emitted from each of said laser diode arrays, said emitting regions defining an emitting area and wherein said printed circuit board has a board area, the ratio of said board area to said emitting area being less than approximately 10.

23. A method of operating a laser diode array comprising the steps of:

providing a laser diode array (30) having an associated integral memory device (42) mounted on an intermediate structure (46) to which said laser diode array (30) is attached;

storing operating data for said laser diode array (30) in said associated memory device (42).

assembling said laser diode array (30) into an operating system having drive electronics and a controller (143), said drive electronics being coupled to said laser diode array (30), said controller (143) being coupled to said drive electronics and to said associated memory device (42);

instructing said controller (143) to retrieve said operating data from said associated memory device (42);

powering said drive electronics at an electrical drive state corresponding to said operating data to produce output energy from said laser diode array;

characterized in that the method further comprises the step of updating at least one specific operating condition experienced by said laser diode array (30) in said memory device (42) during use of said laser diode array (30).

24. The method of claim 23, further including the steps of:

monitoring an operating condition of said laser diode array with at least one sensor;

selecting other operating data in response to said operating condition monitored by said at least one sensor; and

instructing said controller to retrieve said other operating data so as to modify said electrical drive state.

25. The method of claim 24, wherein said at least one sensor is a temperature sensor measuring a temperature of said laser diode array, an optical output sensor for monitoring the output energy of said laser diode array, or a wavelength sensor for monitoring a wavelength of the output energy of said laser diode array.

26. The method of claims 23-25, wherein said operating data is capable of being externally altered throughout the lifetime of said laser diode array.

27. The method of claim 26, wherein said controller of said operating system alters said operating data by recording in said memory device updated operating

data due to self-calibration.

28. The method of claim 23, wherein said at least one operating condition is a shot-count or on-time of said laser diode array.

29. The method of claim 23, wherein said at least one specific operating condition includes a maximum temperature of said at least one laser diode array, a maximum power supplied to said at least one laser diode array, a total on-time or shot-count of said at least one laser diode array, or a maximum ambient condition to which said at least one laser diode array is subjected.

30. The method of claim 23, wherein said at least one specific operating condition includes a fault condition experienced by said at least one laser diode array, said fault condition being one of the group consisting of a reverse-bias fault, a coolant flow fault, an extreme power input fault, an extreme temperature fault, and an electrostatic discharge fault.

31. The modular laser diode array assembly of claim 1, wherein said operating information includes wavelength of said output energy as a function of temperature of said laser diode array.

32. The modular laser diode array assembly of claim 1, wherein said operating information includes identifying the type of said at least one laser diode array such as by serial number, lot number of said at least one laser diode, or wafer number of said at least one laser diode array.

33. The modular laser diode array assembly of claim 1, wherein said operating information includes an initial voltage drop across said at least one laser diode array for comparison with a voltage drop during use of said at least one laser diode array to detect failures.

34. The modular laser diode array assembly of claim 1, wherein said operating information includes the expected amount or wavelength of said output energy of said at least one laser diode array as a function of input current.

Patentansprüche

1. Modulare Laserdiodenarray-Anordnung mit:

   mindestens einem Laserdiodenarray (30) mit mehreren Laserdioden (13), wobei jede der mehreren Laserdioden zur Umwandlung elektrischer Energie in optische Energie dient;

   einer Zwischenstruktur (46), an der das mindestens eine Laserdiodenarray befestigt ist; und

   einem Speicherelem nt (42), das an der Zwischenstruktur (46) montiert ist, so dass diese integral in dem mindestens einem Laserdiodenarray angeordnet ist, wobei das Speicherelement (42) zum Speichern von Betriebsinformationen für mindestens ein Laserdiodenarray dient,

   dadurch gekennzeichnet, dass
   das Speichern der Betriebsinformationen das Aktualisieren zumindest einer spezifischen Betriebsbedingung, die von dem mindestens einem Laserdiodenarray (30) während des Betriebs erfahren wird, umfasst.

2. Die modulare Laserdiodenarray-Anordnung nach Anspruch 1, wobei die Betriebsinformation die Serienidentität des mindestens einen Laserdiodenarrays umfasst.

3. Die modulare Laserdiodenarray-Anordnung nach Anspruch 1, wobei die Betriebsinformation eine Abschätzung einer Ausgangsenergieverschlechterung über die Lebensdauer des mindestens einen Laserdiodenarrays, eine Wellenlänge der Ausgangsenergie als eine Funktion der Temperatur des mindestens einen Laserdiodenarrays oder eine Ausgangsenergie des mindestens einen Laserdiodenarrays als eine Funktion der Eingangsleistung umfasst.

4. Die modulare Laserdiodenarray-Anordnung nach einem der Ansprüche 1-3, wobei das Speicherelement mit einem externen Betriebssystem verbunden ist, das in dem Speicherelement aktualisierte Betriebsinformationen auf der Basis des Leistungsverhaltens des mindestens einen Laserdiodenarrays aufzeichnet.

5. Die modulare Laserdiodenarray-Anordnung nach einem der Ansprüche 1-4, wobei das Speicherelement mit einem externen Betriebssystem verbunden ist, das in dem Speicherelement die spezifischen Betriebsbedingungen aufzeichnet, die von dem mindestens einem Laserdiodenarray erfahren werden.

6. Die modulare Laserdiodenarray-Anordnung nach einem der Ansprüche 1-5, wobei die Betriebsinformation zumindest eine spezifische Betriebsbedingung umfasst, die von dem mindestens einem Laserdiodenarray während des Betriebs erfahren wird, wobei die spezifische Betriebsbedingung, die in dem Speicherelement aufgezeichnet ist, den Zeitpunkt des Auftretens der Betriebsbedingung

einschließt.

7. Die modulare Laserdiodenarray-Anordnung nach einem der Ansprüche 1-6, die ferner einen Temperatursensor zum Bereitstellen einer Temperatur des mindestens einen Laserdiodenarrays umfasst.

8. Die modulare Laserdiodenarray-Anordnung nach Anspruch 7, die ferner eine Einrichtung zum Abführen von Wärme von dem mindestens einem Laserdiodenarray aufweist, wobei die Wärmeabführeinrichtung bei einem spezifizierten Pegel betrieben wird, der durch die Betriebsinformation entsprechend zu einer mittels des Temperatursensors überwachten Temperatur bestimmt ist.

9. Die modulare Laserdiodenarray-Anordnung nach einem der Ansprüche 1-8, die ferner einen optischen Sensor zum Bereitstellen optischer Eigenschaften des Arrays umfasst.

10. Die modulare Laserdiodenarray-Anordnung nach einem der Ansprüche 1-9, wobei die Zwischenstruktur eine bedruckte Leiterplatte umfasst, auf der das Speicherelement montiert ist, wobei die gedruckte Leiterplatte eine Oberfläche aufweist, auf der das mindestens eine Laserdiodenarray montiert ist.

11. Die modulare Laserdiodenarray-Anordnung nach Anspruch 1, die ferner umfasst:

   zumindest einen Sensor zum Erfassen von Betriebsbedingungen, die von dem mindestens einem Laserdiodenarray erfahren werden, einschließlich der spezifischen Betriebsbedingungen, die in dem Speicherelement zu speichern sind; und

   eine Verarbeitungseinrichtung, die auf der Zwischenstruktur befestigt und mit dem zumindest einem Sensor zur Überwachung der Betriebsbedingungen verbunden ist, wobei die Verarbeitungseinrichtung mit dem Speicherelement und einem externen Betriebssystem verbunden ist.

12. Die modulare Laserdiodenarray-Anordnung nach Anspruch 11, wobei das Speicherelement in der Verarbeitungseinrichtung enthalten ist.

13. Die modulare Laserdiodenarray-Anordnung nach einem der Ansprüche 11-12, wobei die Verarbeitungseinrichtung die zumindest eine spezifische Betriebsbedingung, die von dem zumindest einem Sensor erfasst ist, in dem Speicherelement aufzeichnet.

14. Die modulare Laserdiodenarray-Anordnung nach einem der Ansprüche 1-13, wobei die Betriebsinformation zumindest eine spezifische Betriebsbedingung, die von dem mindestens inen Laserdiodenarray während des Betriebs erfahren wird, umfasst, wobei die zumindest eine spezifische Betriebsbedingung eine maximale Temperatur des mindestens einen Laserdiodenarrays, eine maximale Leistung, die dem mindestens einem Laserdiodenarray zugeführt ist, eine Gesamteinschaltzeit oder eine Gesamtpulszahl des mindestens einen Laserdiodenarrays, oder eine maximale Umgebungsbedingung, der das mindestens eine Laserdiodenarray ausgesetzt ist, umfasst.

15. Die modulare Laserdiodenarray-Anordnung nach einem der Ansprüche 1-13, wobei die Betriebsinformation zumindest eine spezifische Betriebsbedingung, die von dem mindestens einem Laserdiodenarray während des Betriebs erfahren wird, umfasst, wobei die zumindest eine spezifische Betriebsbedingung eine von dem mindestens einen Laserdiodenarray erfahrene Fehlerbedingung umfasst, wobei die Fehlerbedingung eine der folgenden ist: Inversvorspannungsfehler, Kühlmittelflussfehler, Eingangsleistungsüberschreitungsfehler, Extremtemperaturfehler und Fehlfunktion durch elektrostatische Entladung.

16. Die modulare Laserdiodenarray-Anordnung nach Anspruch 11, wobei der zumindest eine Sensor einen Temperatursensor zur Messung einer Temperatur des mindestens einen Laserdiodenarrays, einen optischen Sensor zur Messung der Ausgangsenergie des mindestens einen Laserdiodenarrays, eine optischen Sensor zur Messung der Ausgangswellenlänge der Ausgangsenergie des mindestens einen Laserdiodenarrays, einen Spannungssensor zum Messen der Spannung über dem mindestens einen Laserdiodenarray oder einen Stromsensor, der zwischen dem Versorgungsspannungskontaktanschlüssen angeordnet ist, zum Messen des Stromes durch das mindestens eine Laserdiodenarray umfasst.

17. Die modulare Laserdiodenarray-Anordnung nach einem der Ansprüche 11-16, wobei die Verarbeitungseinrichtung das externe Betriebssystem anweist, das zumindest eine Laserdiodenarray mit einem Leistungspegel anzusteuern, der durch die in dem Speicherelement gespeicherte Betriebsinformation abgegrenzt ist.

18. Die modulare Laserdiodenarray-Anordnung nach Anspruch 17, wobei der Leistungspegel auf der Grundlage der Betriebsbedingungen, die von der Verarbeitungseinrichtung über den zumindest einen Sensor überwacht sind, aktualisiert wird.

19. Die modulare Laserdiodenarray-Anordnung nach Anspruch 11, die ferner eine Einrichtung umfasst, um Wärme aus dem mindestens einen Laserdiodenarray abzuführen, und wobei der zumindest eine Sensor einen Temperatursensor umfasst, wobei die Verarbeitungseinrichtung die Wärmeabführeinrichtung auf einen spezifizierten Wert hinsteuert, der durch die Betriebsinformation entsprechend einer mittels des Temperatursensors überwachten Temperatur bestimmt ist.

20. Die modulare Laserdiodenarray-Anordnung nach Anspruch 11, wobei die Zwischenstruktur eine gedruckte Leiterplatte umfasst, auf der das Speicherelement und die Verarbeitungseinrichtung montiert sind, wobei die gedruckte Schaltungsplatte ferner eine Oberfläche aufweist, auf der das mindestens eine Laserdiodenarray montiert ist.

21. Die modulare Laserdiodenarray-Anordnung nach Anspruch 10 oder 20, wobei die gedruckte Leiterplatte eine Verbindung umfasst, mit der das externe Betriebssystem verbunden ist.

22. Die modulare Laserdiodenarray-Anordnung nach Anspruch 10 oder 20, wobei das mindestens eine Laserdiodenarray ein Emissionsgebiet aufweist, an dem Energie von jedem der Laserdiodenarrays ausgesendet wird, wobei die Emissionsgebiete eine Emissionsfläche definieren und wobei die gedruckte Leiterplatte eine Platinenfläche aufweist, wobei das Verhältnis der Platinenfläche zu der Emissionsfläche kleiner als ungefähr 10 ist.

23. Verfahren zum Betreiben eines Laserdiodenarrays mit den Schritten:

Bereitstellen eines Laserdiodenarrays (30) mit einem zugeordneten integralen Speicherelement (42), das auf einer Zwischenstruktur (46) befestigt ist, auf dem das Laserdiodenarray (30) angebracht ist;

Speichern von Betriebsdaten für das Laserdiodenarray (30) in dem zugeordneten Speicherelement (42);

Einbinden des Laserdiodenarrays (30) in ein Betriebssystem mit Ansteuerelektronik und einem Kontroller (143), wobei die Ansteuerelektronik mit dem Laserdiodenarray (30) verbunden ist, wobei der Kontroller (143) mit der Ansteuerelektronik und dem zugeordneten Speicherelement (42) verbunden ist;

Instruieren des Kontrollers (143), um die Betriebsdaten aus dem zugeordneten Speicherelement (42) abzurufen;

Versorgen der Ansteuerelektronik mit Leistung gemäß einem elektrischen Ansteuerzustand entsprechend zu den Betriebsdaten, um Ausgangsenergie aus dem Laserdiodenarray zu erzeugen;

dadurch gekennzeichnet, dass das Verfahren ferner den Schritt aufweist:
Aktualisieren zumindest einer spezifischen Betriebsbedingung, die von dem Laserdiodenarray (30) erfahren wird, in dem Speicherelement (42) während der Verwendung des Laserdiodenarrays (30).

24. Das Verfahren nach Anspruch 23, das ferner die Schritte umfasst:

Überwachen einer Betriebsbedingung des Laserdiodenarrays mit zumindest einem Sensor;

Auswählen anderer Betriebsdaten in Reaktion auf die Betriebsbedingung, die von dem zumindest einem Sensor überwacht ist; und

Instruieren des Kontrollers, um die anderen Betriebsdaten abzurufen, um den elektrischen Ansteuerzustand zu modifizieren.

25. Das Verfahren nach Anspruch 24, wobei der zumindest eine Sensor ein Temperatursensor zum Messen einer Temperatur des Laserdiodenarrays, ein optischer Ausgangsleistungssensor zum Überwachen der Ausgangsenergie des Laserdiodenarrays oder ein Wellenlängensensor zum Überwachen einer Wellenlänge der Ausgangsenergie des Laserdiodenarrays ist.

26. Das Verfahren nach einem der Ansprüche 23-25, wobei die Betriebsdaten so gestaltet sind, um extern während der Lebensdauer des Laserdiodenarrays veränderbar zu sein.

27. Das Verfahren nach Anspruch 26, wobei der Kontroller des Betriebssystems die Betriebsdaten durch Aufzeichnen aktualisierter Betriebsdaten in dem Speicherelement aufgrund von Selbstkalibrierung ändert.

28. Das Verfahren nach Anspruch 23, wobei die zumindest eine Betriebsbedingung eine Pulszahl oder eine Einschaltdauer des Laserdiodenarrays ist.

29. Das Verfahren nach Anspruch 23, wobei die zumindest eine spezifische Betriebsbedingung eine maximale Temperatur des Laserdiodenarrays, eine maximale dem Laserdiodenarray zugeführte Leistung, eine Gesamteinschaltdauer oder eine Gesamtpulszahl des Laserdiodenarrays oder eine ma-

ximale Umgebungstemperatur, der das Laserdiodenarray ausgesetzt ist, umfasst.

30. Das Verfahren nach Anspruch 23, wobei die zumindest eine spezifische Betriebsbedingung eine Fehlerbedingung umfasst, die von dem Laserdiodenarray erfahren wird, wobei die Fehlerbedingung einer der folgenden ist: Inversvorspannungsfehler, Kühlmittelflussfehler, Eingangsleistungsübertretungsfehler, Extremtemperaturfehler, und Fehlfunktion aufgrund elektrostatischer Entladung.

31. Die modulare Laserdiodenarray-Anordnung nach Anspruch 1, wobei die Betriebsinformation die Wellenlänge der Ausgangsenergie als eine Funktion der Temperatur des Laserdiodenarrays umfasst.

32. Die modulare Laserdiodenarray-Anordnung nach Anspruch 1, wobei die Betriebsinformation die Identifizierung der Art des zumindest einen Laserdiodenarrays, etwa die Seriennummer, die Losnummer der mindestens einen Laserdiode oder die Waferzahl der zumindest einen Laserdiodenarray umfasst.

33. Die modulare Laserdiodenarray-Anordnung nach Anspruch 1, wobei die Betriebsinformation einen anfänglichen Spannungsabfall über dem mindestens einen Laserdiodenarray zum Vergleich mit einem Spannungsabfall während der Verwendung des mindestens einen Laserdiodenarrays zur Erfassung von Fehlfunktionen umfasst.

34. Die modulare Laserdiodenarray-Anordnung nach Anspruch 1, wobei die Betriebsinformation die erwartete Wellenlänge der Ausgangsenergie des mindestens einen Laserdiodenarrays als eine Funktion des Eingangsstromes beinhaltet.

Revendications

1. Arrangement de diodes laser modulaire, comprenant :

au moins un arrangement de diodes laser (30) comprenant une pluralité de diodes laser pour convertir l'énergie électrique en énergie optique ;
une structure intermédiaire (46) à laquelle au moins un arrangement de diodes laser est fixé ; et
un dispositif à mémoire (42) monté sur ladite structure intermédiaire (46) de façon à être intégré avec ledit au moins un arrangement de diodes laser, ledit dispositif à mémoire (42) permettant de stocker des informations de fonctionnement pour au moins un arrangement de diodes laser, **caractérisé n ce qu** le stockage desdites informations de fonctionnement comprend la mise à jour d'au moins une condition de fonctionnement spécifique rencontrée par ledit au moins un arrangement de diodes laser (30) pendant le fonctionnement.

2. Arrangement de diodes laser modulaire selon la revendication 1, dans lequel lesdites informations de fonctionnement comprennent l'identité de sérialisation dudit au moins un arrangement de diodes laser.

3. Arrangement de diodes laser modulaire selon la revendication 1, dans lequel lesdites informations de fonctionnement comprennent une estimation de la dégradation d'énergie en sortie au cours de la durée d'utilisation dudit au moins un arrangement de diodes laser, la longueur d'onde de l'énergie en sortie en fonction de la température dudit au moins un arrangement de diodes laser, ou l'énergie en sortie dudit au moins un arrangement de diodes laser en fonction de l'énergie en entrée.

4. Arrangement de diodes laser modulaire selon les revendications 1 à 3, dans lequel ledit dispositif à mémoire est connecté à un système d'exploitation externe qui enregistre dans ledit dispositif à mémoire des informations de fonctionnement mises à jour basées sur les performances dudit au moins un arrangement de diodes laser.

5. Arrangement de diodes laser modulaire selon les revendications 1 à 4, dans lequel ledit dispositif à mémoire est connecté à un système d'exploitation externe qui enregistre dans ledit dispositif à mémoire lesdites conditions de fonctionnement rencontrées par ledit au moins un arrangement de diodes laser.

6. Arrangement de diodes laser modulaire selon les revendications 1 à 5, dans lequel lesdites informations de fonctionnement comprennent au moins une condition de fonctionnement spécifique rencontrée par ledit au moins un arrangement de diodes laser pendant le fonctionnement, ladite condition de fonctionnement spécifique enregistrée dans ledit dispositif à mémoire comprend le moment auquel ladite condition de fonctionnement est survenue.

7. Arrangement de diodes laser modulaire selon les revendications 1 à 6, comprenant également un capteur de température pour fournir la température dudit au moins un arrangement de diodes laser.

8. Arrangement de diodes laser modulaire selon la revendication 7, comprenant également un moyen pour éliminer la chaleur dudit au moins un arrange-

ment de diodes laser, ledit moyen d'élimination de chaleur étant commandé à un niveau spécifié déterminé par lesdites informations de fonctionnement correspondant à la température détectée par l'intermédiaire dudit capteur de température.

9. Arrangement de diodes laser modulaire selon les revendications 1 à 8, comprenant également un capteur optique pour fournir des caractéristiques optiques de ladite arrangement.

10. Arrangement de diodes laser modulaire selon les revendications 1 à 9, dans lequel ladite structure intermédiaire comprend une carte à circuits imprimés sur laquelle ledit dispositif à mémoire est monté, ladite carte à circuits imprimés comprenant également une surface sur laquelle ladite au moins un arrangement de diodes laser est monté.

11. Arrangement de diodes laser modulaire selon la revendication 1, comprenant également :

au moins un capteur pour détecter des conditions de fonctionnement rencontrées par ledit au moins un arrangement de diodes laser comprenant lesdites conditions de fonctionnement spécifiques à stocker dans ledit dispositif à mémoire ; et

un moyen de traitement monté sur ladite structure intermédiaire et connecté audit au moins un capteur pour détecter lesdites conditions de fonctionnement, ledit moyen de traitement étant connecté audit dispositif à mémoire et à un système d'exploitation externe.

12. Arrangement de diodes laser modulaire selon la revendication 11, dans lequel ledit dispositif à mémoire est inclus dans ledit moyen de traitement.

13. Arrangement de diodes laser modulaire selon les revendications 11 à 12, dans lequel ledit moyen de traitement enregistre au moins une condition de fonctionnement spécifique détectée par ledit au moins un capteur dans ledit dispositif à mémoire.

14. Arrangement de diodes laser modulaire selon les revendications 1 à 13, dans lequel lesdites informations de fonctionnement comprennent au moins une condition de fonctionnement spécifique rencontrée par ledit au moins un arrangement de diodes laser pendant le fonctionnement, ladite au moins une condition de fonctionnement spécifique comprenant la température maximale dudit au moins un arrangement de diodes laser, la puissance maximale transmise audit au moins un arrangement de diodes laser, la durée ou le nombre de coups total dudit au moins un arrangement de diodes laser, ou une condition ambiante maximale à laquelle ledit au moins un arrangement de diodes laser est exposé.

15. Arrangement de diodes laser modulaire selon les revendications 1 à 13, dans lequel lesdites informations de fonctionnement comprennent au moins une condition de fonctionnement spécifique rencontrée par ledit au moins un arrangement de diodes laser pendant le fonctionnement, ladite au moins une condition de fonctionnement spécifique comprenant une condition d'erreur rencontrée par ledit au moins un arrangement de diodes laser, ladite condition d'erreur étant l'une parmi le groupe comprenant une erreur de polarisation inverse, une erreur de débit de réfrigérant, une erreur d'entrée d'alimentation maximale, une erreur de température maximale, et une erreur de décharge électrostatique.

16. Arrangement de diodes laser modulaire selon la revendication 11, dans lequel ledit au moins un capteur comprend un capteur de température mesurant la température dudit au moins un arrangement de diodes laser, un capteur optique mesurant l'énergie en sortie dudit au moins un arrangement de diodes laser, un capteur optique mesurant la longueur d'onde en sortie de l'énergie en sortie dudit au moins un arrangement de diodes laser, un capteur de tension pour mesurer la tension aux bornes dudit au moins un arrangement de diodes laser, ou un capteur de courant positionné entre lesdites plages de contact d'alimentation pour mesurer le courant traversant ledit au moins un arrangement de diodes laser.

17. Arrangement de diodes laser modulaire selon les revendications 11 à 16, dans lequel ledit moyen de traitement commande audit système d'exploitation externe d'alimenter ledit au moins un arrangement de diodes laser à un niveau de puissance défini par lesdites informations de fonctionnement enregistrées dans ledit dispositif à mémoire.

18. Arrangement de diodes laser modulaire selon la revendication 17, dans lequel ledit niveau de puissance est mis à jour en fonction desdites conditions de fonctionnement détectées par ledit moyen de traitement à l'aide dudit au moins un capteur.

19. Arrangement de diodes laser modulaire selon la revendication 11, comprenant également un moyen pour éliminer la chaleur dudit au moins un arrangement de diodes laser et ledit au moins un capteur comprenant un capteur de température, ledit moyen de traitement contrôlant ledit moyen d'élimination de chaleur à un niveau spécifié déterminé par lesdites informations de fonctionnement correspondant à une température détectée par ledit cap-

teur de température.

20. Arrangement de diodes laser modulaire selon la revendication 11, dans lequel ladite structure intermédiaire comprend une carte à circuits imprimés sur laquelle ledit dispositif à mémoire et ledit moyen de traitement sont montés, ladite carte à circuits imprimés comprenant également une surface sur laquelle ledit au moins un arrangement de diodes laser est monté.

21. Arrangement de diodes laser modulaire selon les revendications 10 ou 20, dans lequel ladite carte à circuits imprimés comprend un connecteur sur lequel ledit système d'exploitation externe est monté.

22. Arrangement de diodes laser modulaire selon les revendications 10 ou 20, dans lequel ledit au moins un arrangement de diodes laser comprend une région émettrice dans laquelle de l'énergie est émise par chacun des arrangements de diodes laser, lesdites régions émettrices définissant une aire émettrice et dans lequel ladite carte à circuits imprimés comprend une aire de carte, le rapport de ladite aire de carte sur ladite aire émettrice étant inférieur à environ 10.

23. Procédé de fonctionnement d'un arrangement de diodes laser comprenant les étapes consistant à :

fournir un arrangement de diodes laser (30) comprenant un dispositif à mémoire associé intégré (42) monté sur une structure intermédiaire (46) auquel ledit arrangement de diodes laser (30) est fixé ;
enregistrer des données de fonctionnement pour ledit arrangement de diodes laser (30) dans ledit dispositif à mémoire (42) ;
assembler ledit arrangement de diodes laser (30) dans un système d'exploitation comprenant l'électronique de commande et un contrôleur (143), ladite électronique de commande étant connectée audit arrangement de diodes laser (30), ledit contrôleur (143) étant couplé à ladite électronique de commande et audit dispositif à mémoire associé (42) ;
commander audit contrôleur (143) d'extraire lesdites données de fonctionnement dudit dispositif à mémoire associé (42) ;
alimenter ladite électronique de commande à un état d'alimentation électrique correspondant auxdites données de fonctionnement pour produire une énergie en sortie depuis ledit arrangement de diodes laser ;

caract´ris´ en c que le procédé comprend également l'étape consistant à mettre à jour au moins une condition de fonctionnement spécifique rencontrée par ledit arrangement de diodes laser (30) dans ledit dispositif à mémoire (42) pendant l'utilisation dudit arrangement de diodes laser (30).

24. Procédé selon la revendication 23, comprenant également les étapes consistant à :

détecter une condition de fonctionnement dudit arrangement de diodes laser avec au moins un capteur ;
sélectionner d'autres données de fonctionnement en réaction à ladite condition de fonctionnement détectée par ledit au moins un capteur ;
et commander audit contrôleur d'extraire lesdites autres données de fonctionnement de façon à modifier l'état d'alimentation électrique.

25. Procédé selon la revendication 24, dans lequel ledit au moins un capteur est un capteur de température mesurant une température dudit arrangement de diodes laser, un capteur de sortie optique pour détecter l'énergie en sortie dudit arrangement de diodes laser, ou un capteur de longueur d'onde pour détecter la longueur d'onde de l'énergie en sortie dudit arrangement de diodes laser.

26. Procédé selon les revendications 23 à 25, dans lequel il est possible de modifier lesdites données de fonctionnement de façon externe au cours de la durée de vie dudit arrangement de diodes laser.

27. Procédé selon la revendication 26, dans lequel ledit contrôleur dudit système d'exploitation modifie lesdites données de fonctionnement en enregistrant dans ledit dispositif à mémoire des données de fonctionnement mises à jour suite à un auto-étalonnage.

28. Procédé selon la revendication 23, dans lequel ladite au moins une condition de fonctionnement est la durée ou le nombre de coups total dudit arrangement de diodes laser.

29. Procédé selon la revendication 23, dans lequel ladite au moins une condition de fonctionnement spécifique comprend la température maximale dudit au moins un arrangement de diodes laser, la puissance maximale transmise audit au moins un arrangement de diodes laser, la durée ou le nombre de coups total dudit au moins un arrangement de diodes laser, ou une condition ambiante maximale à laquelle ledit au moins un arrangement de diodes laser est exposé.

30. Procédé selon la revendication 23, dans lequel ladite au moins une condition d fonctionnement spécifique comprend une condition d'erreur rencontrée par ledit au moins un arrangement de diodes laser,

ladite condition d'erreur étant l'une parmi le groupe comprenant une erreur de polarisation inverse, une erreur de débit de réfrigérant, une erreur d'entrée d'alimentation maximale, une erreur de température maximale, et une erreur de décharge électrostatique.

31. Arrangement de diodes laser modulaire selon la revendication 1, dans lequel lesdites informations de fonctionnement comprennent la longueur d'onde de ladite énergie de sortie en fonction de la température dudit au moins un arrangement de diodes laser.

32. Arrangement de diodes laser modulaire selon la revendication 1, dans lequel lesdites informations de fonctionnement comprennent l'identification du type dudit au moins un arrangement de diodes, tel que le numéro de série, le numéro de lot dudit au moins un arrangement de diodes, ou le numéro de plaquette dudit au moins un arrangement de diodes.

33. Arrangement de diodes laser modulaire selon la revendication 1, dans lequel lesdites informations de fonctionnement comprennent la chute de tension initiale aux bornes dudit au moins un arrangement de diodes pour comparaison à la chute de tension pendant l'utilisation dudit au moins un arrangement de diodes, afin de détecter les pannes.

34. Arrangement de diodes laser modulaire selon la revendication 1, dans lequel lesdites informations de fonctionnement comprennent la quantité ou la longueur d'onde attendue de ladite énergie de sortie dudit au moins un arrangement de diodes en fonction du courant en entrée.

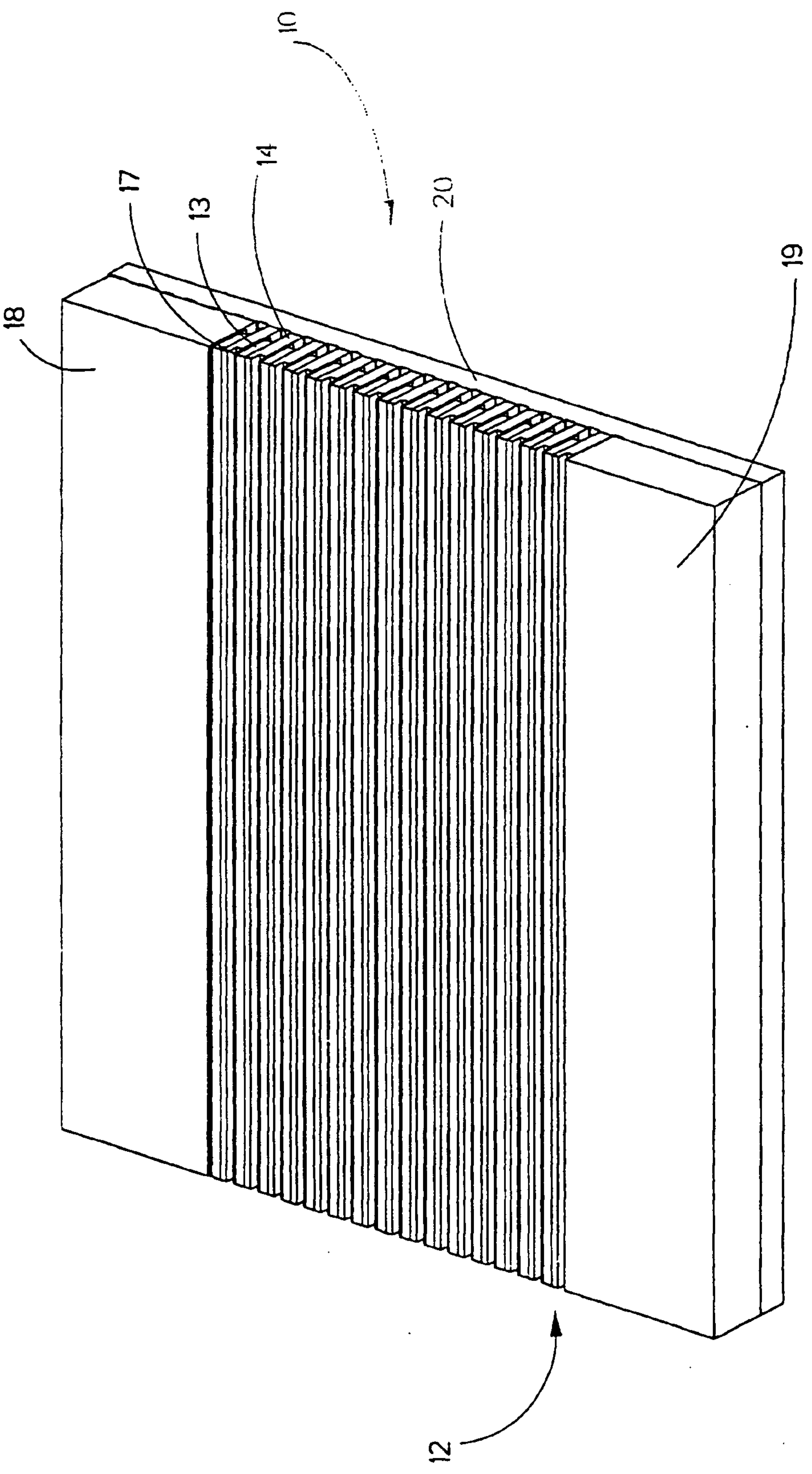


FIGURE 1A

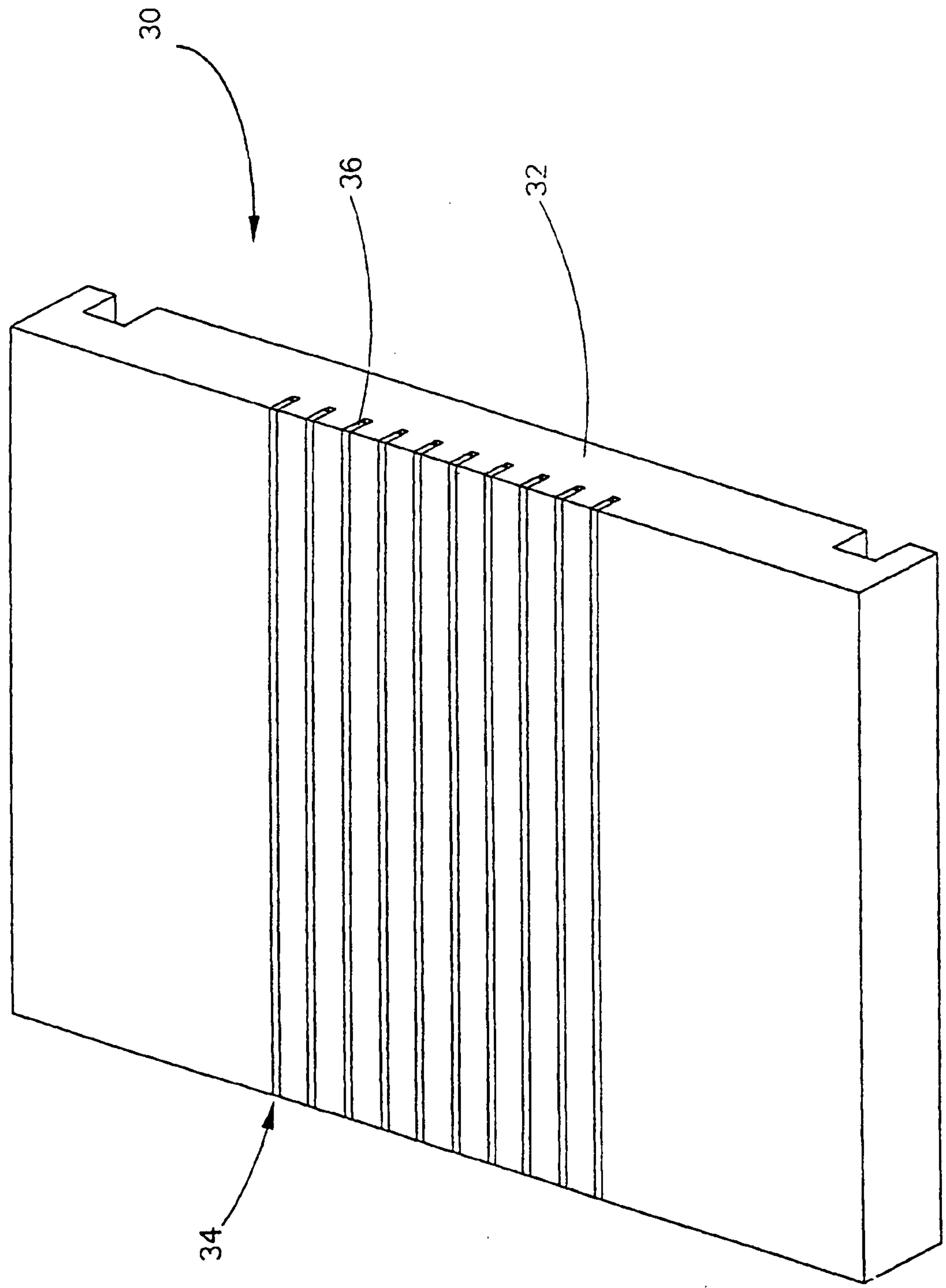


FIGURE 1B

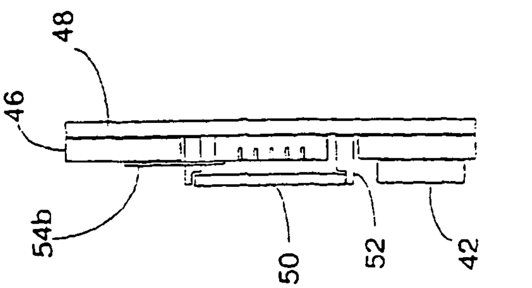


FIGURE 2C

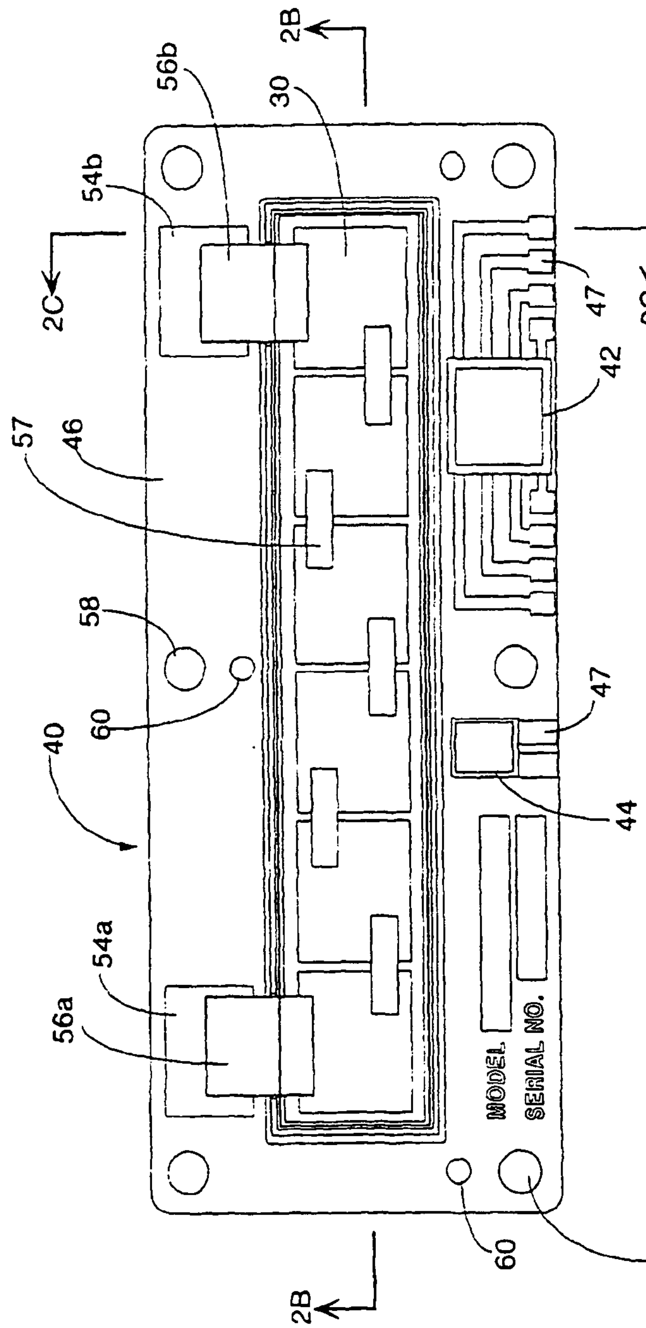


FIGURE 2A

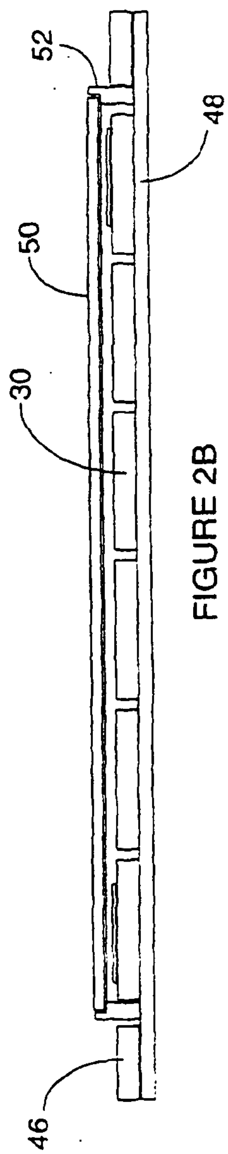


FIGURE 2B

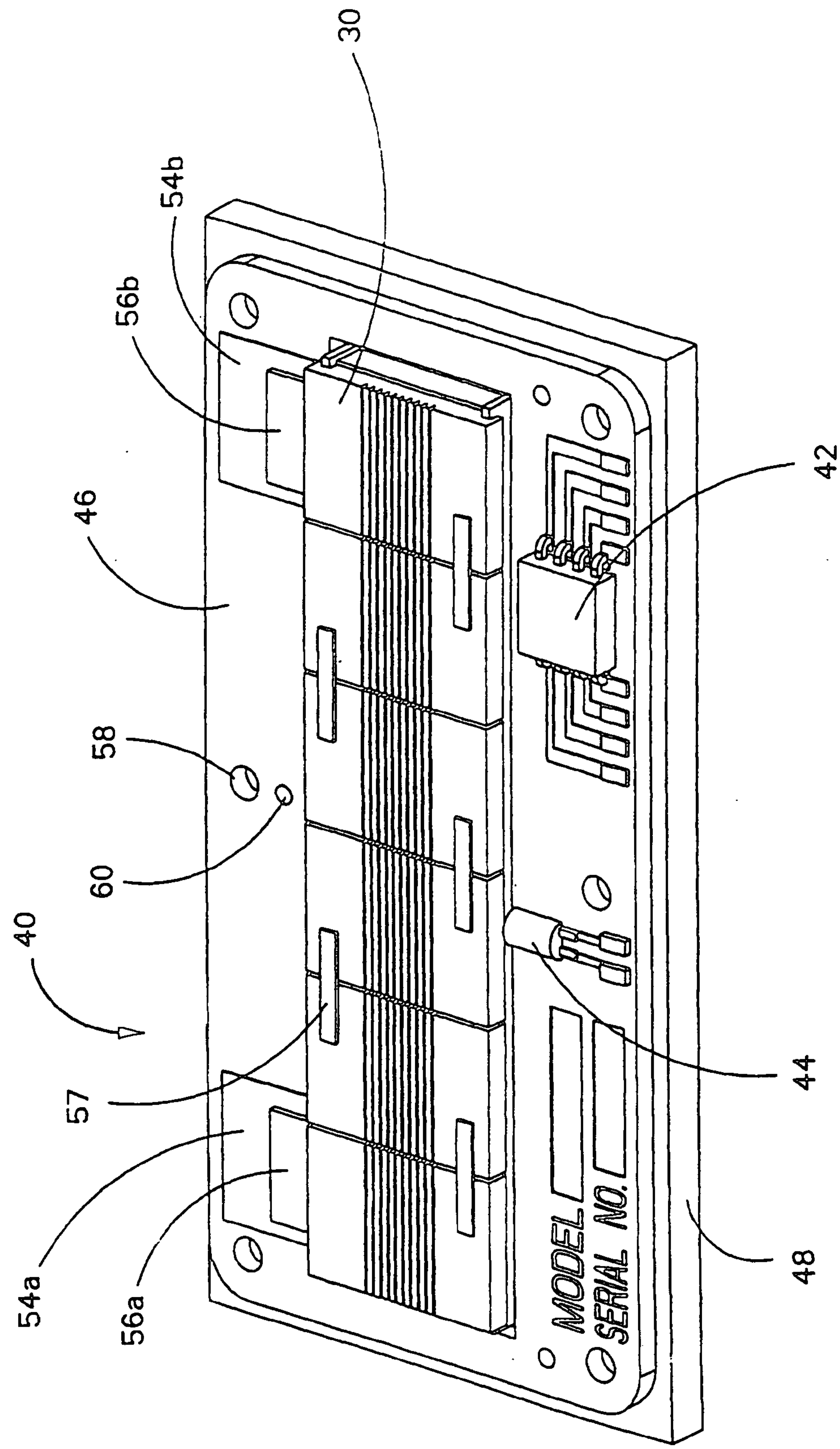


FIGURE 2D

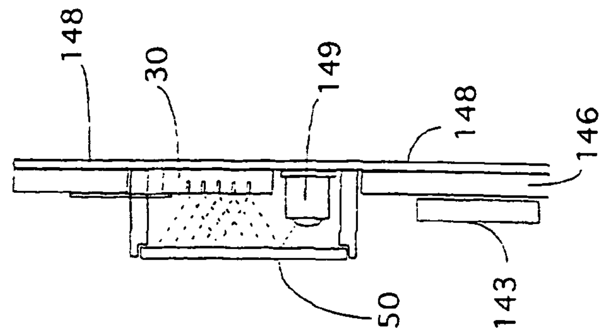


FIGURE 3C

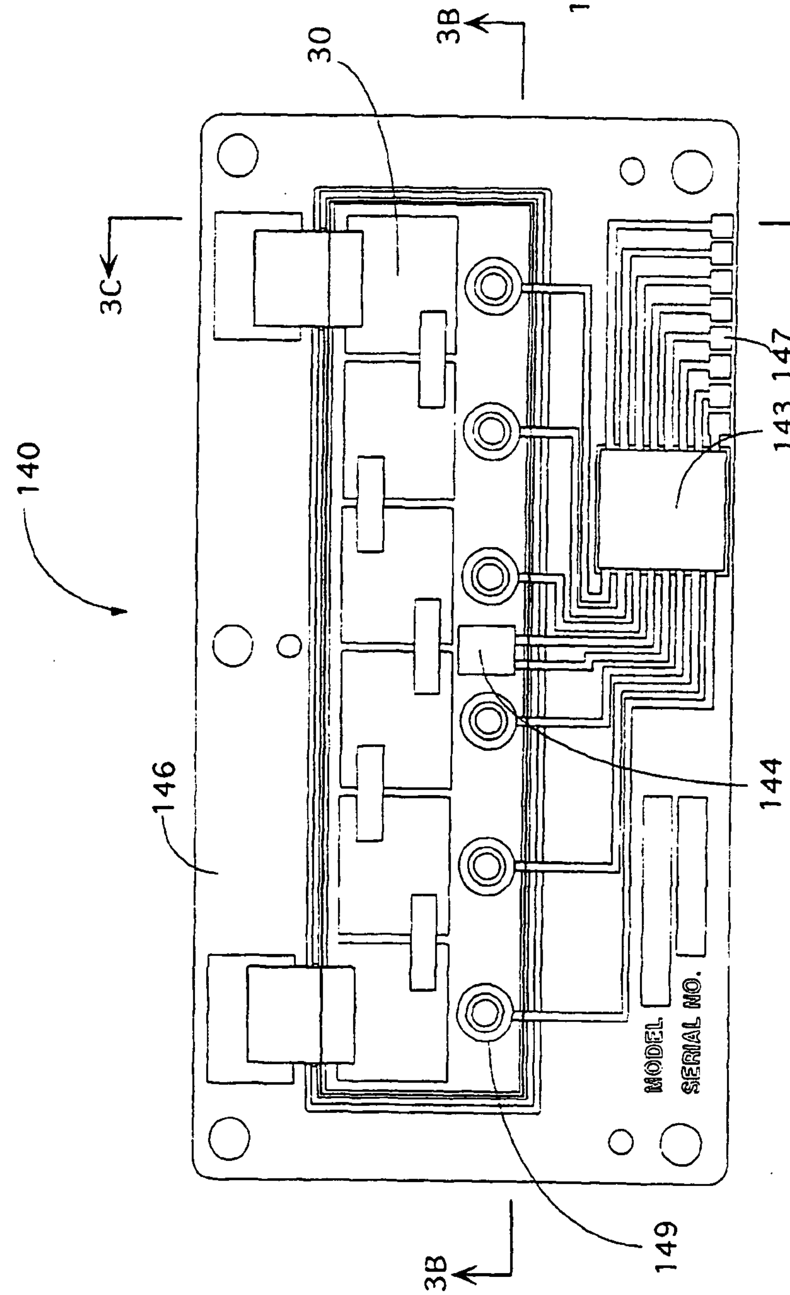


FIGURE 3A

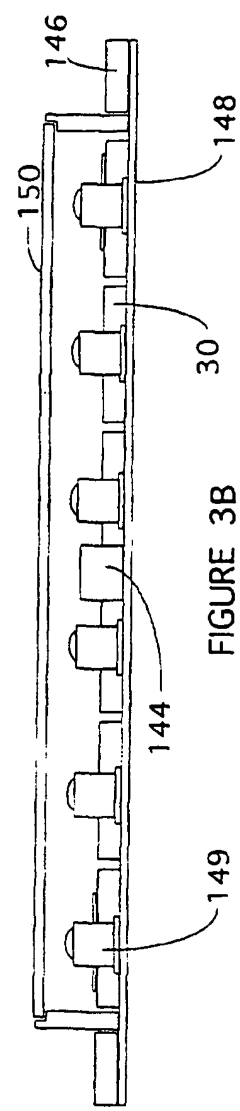


FIGURE 3B

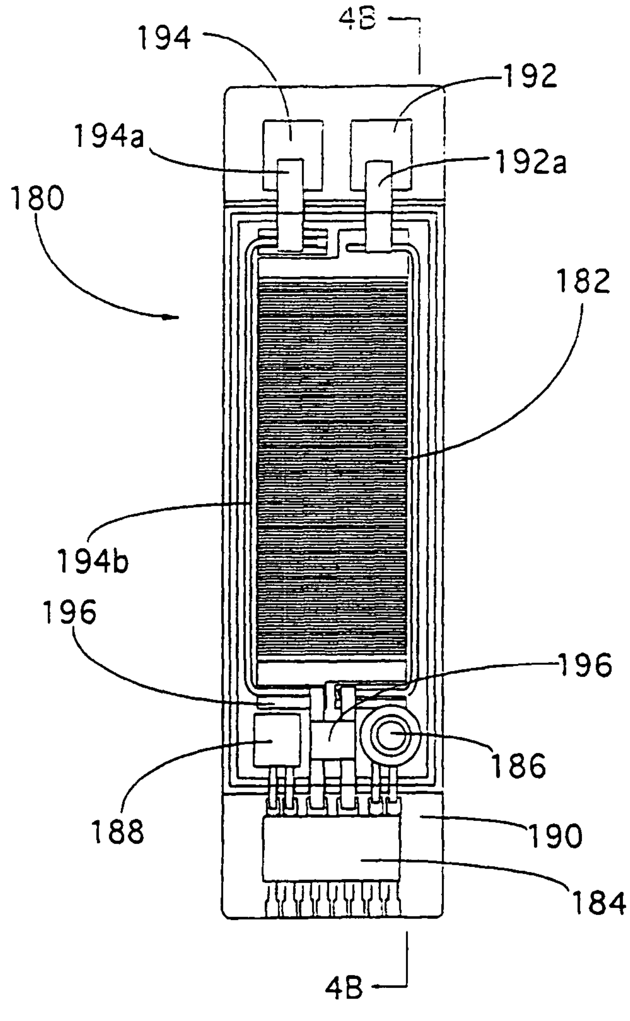


FIGURE 4A

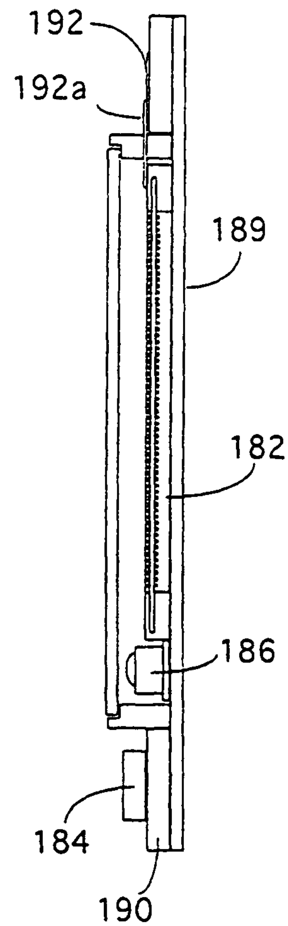


FIGURE 4B

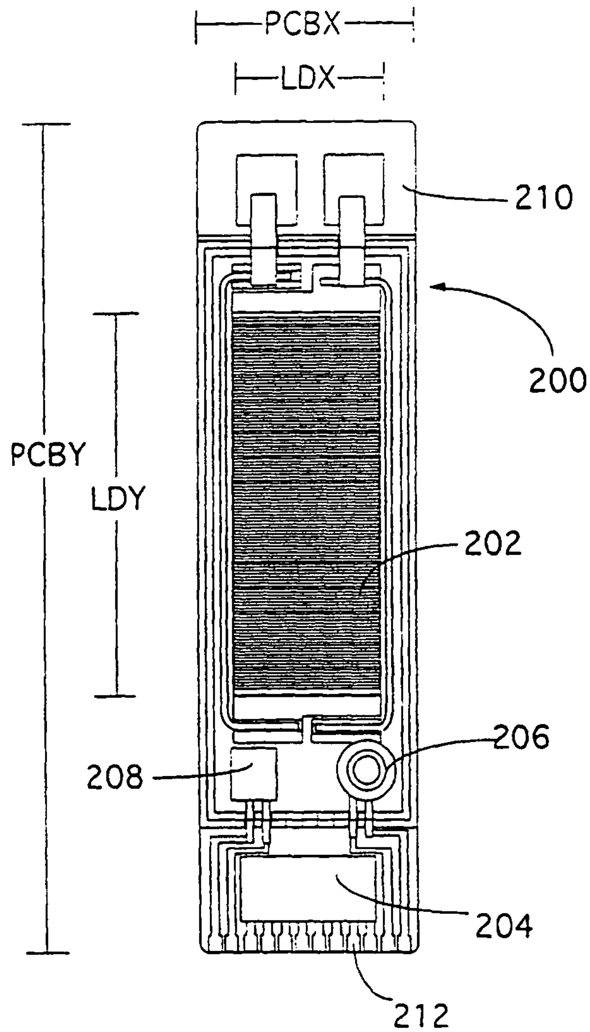


FIGURE 5

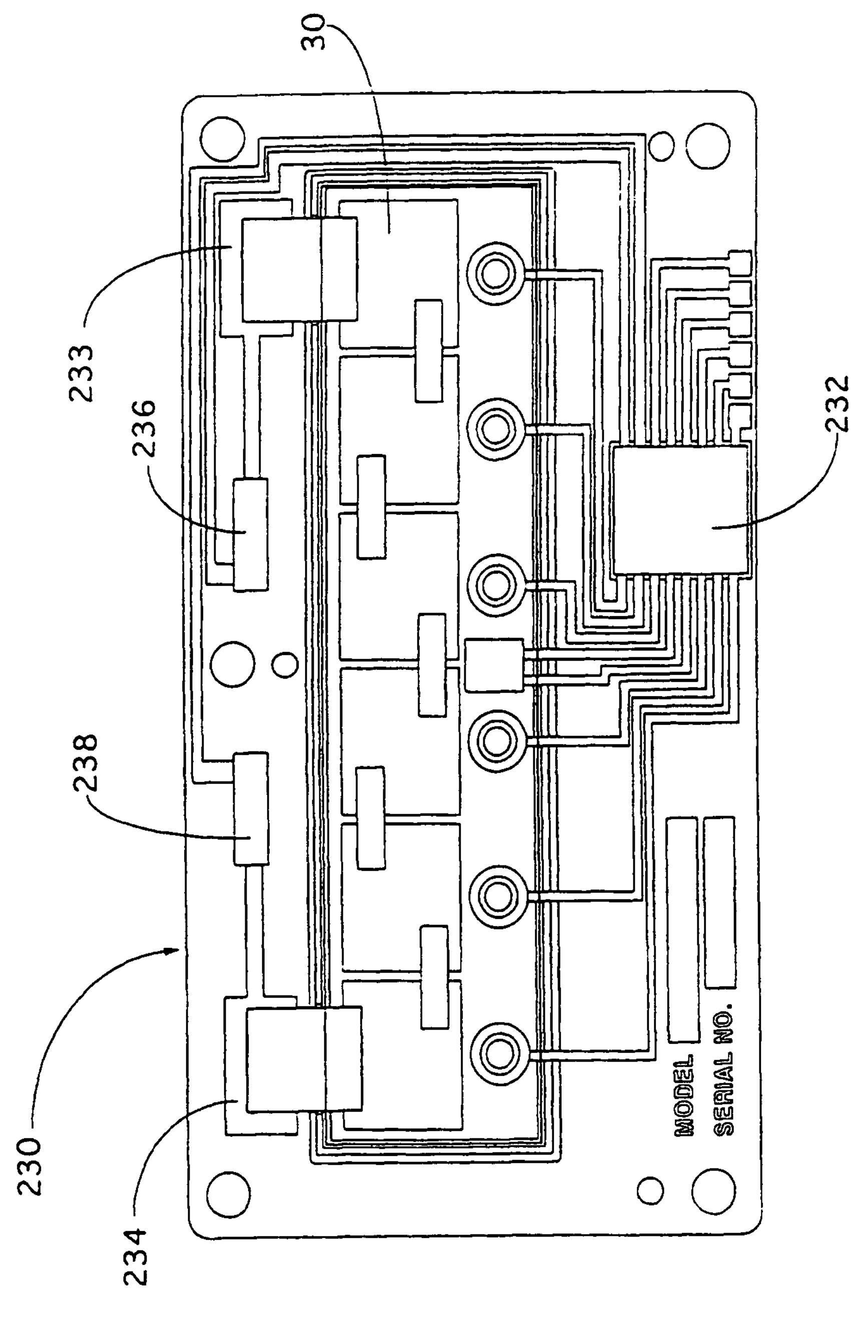


FIGURE 6

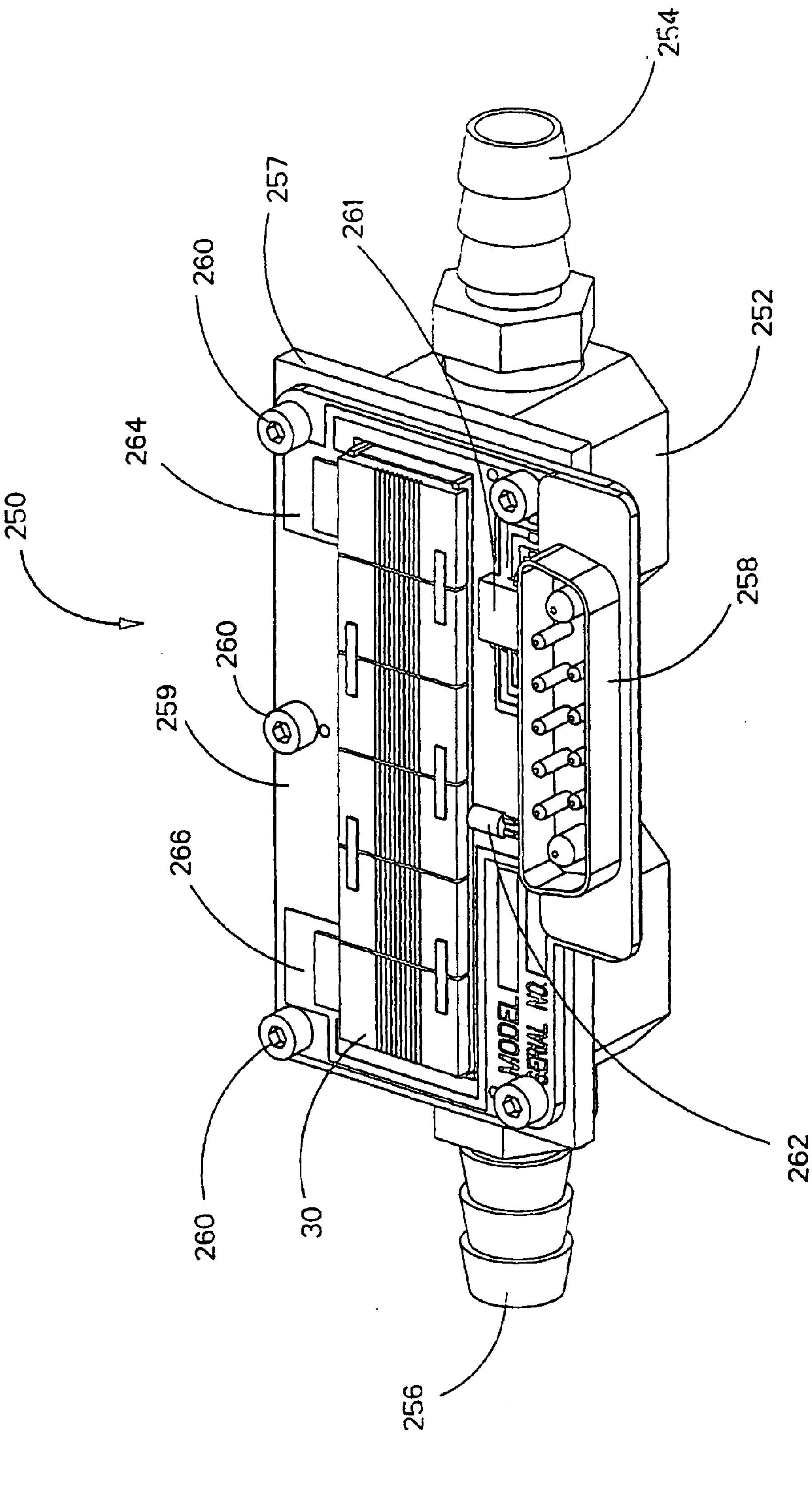

254
257
261
260
252
264
250
258
260
259
266
MODEL
SERIAL NO.
260
30
262
256

FIGURE 7

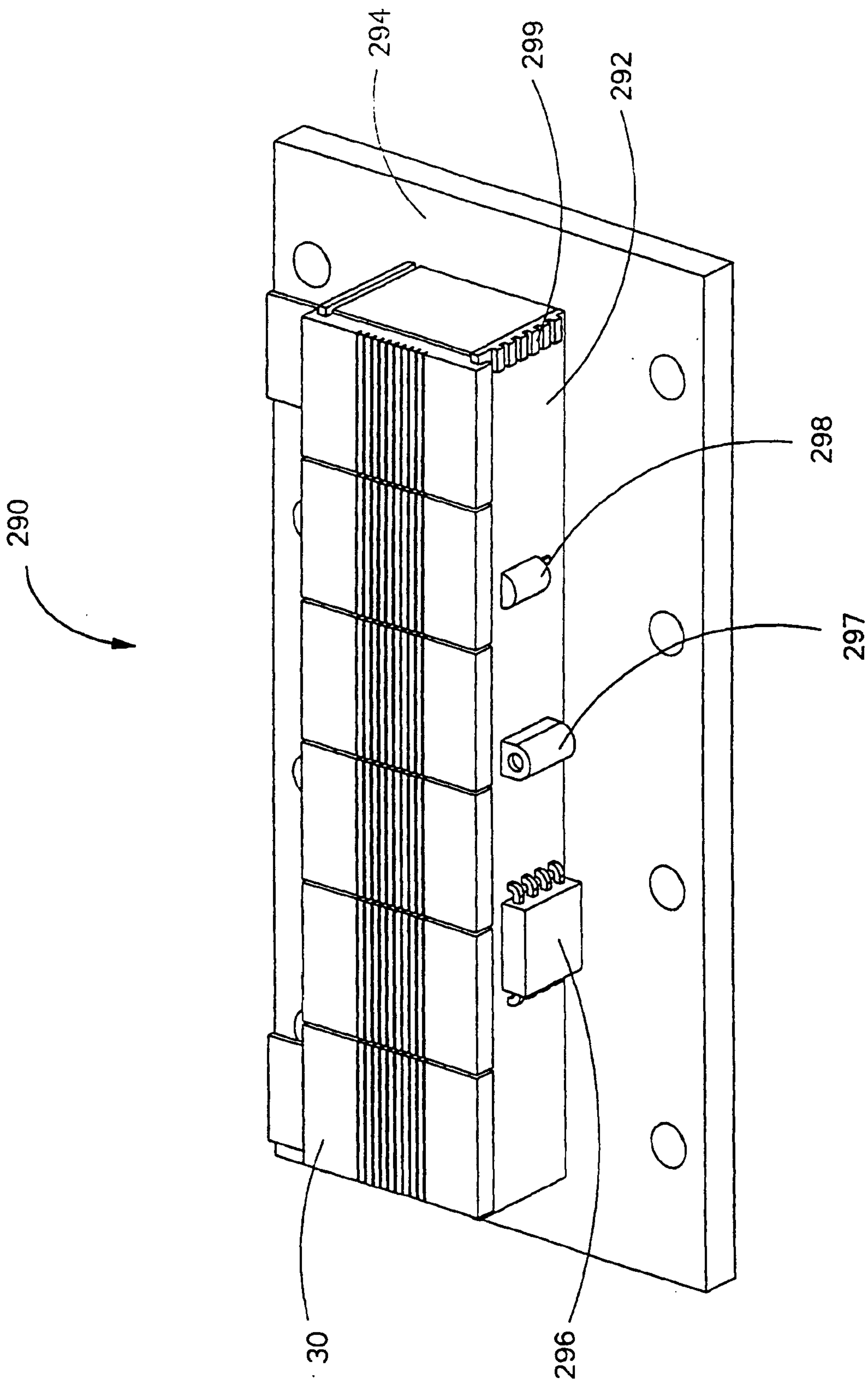
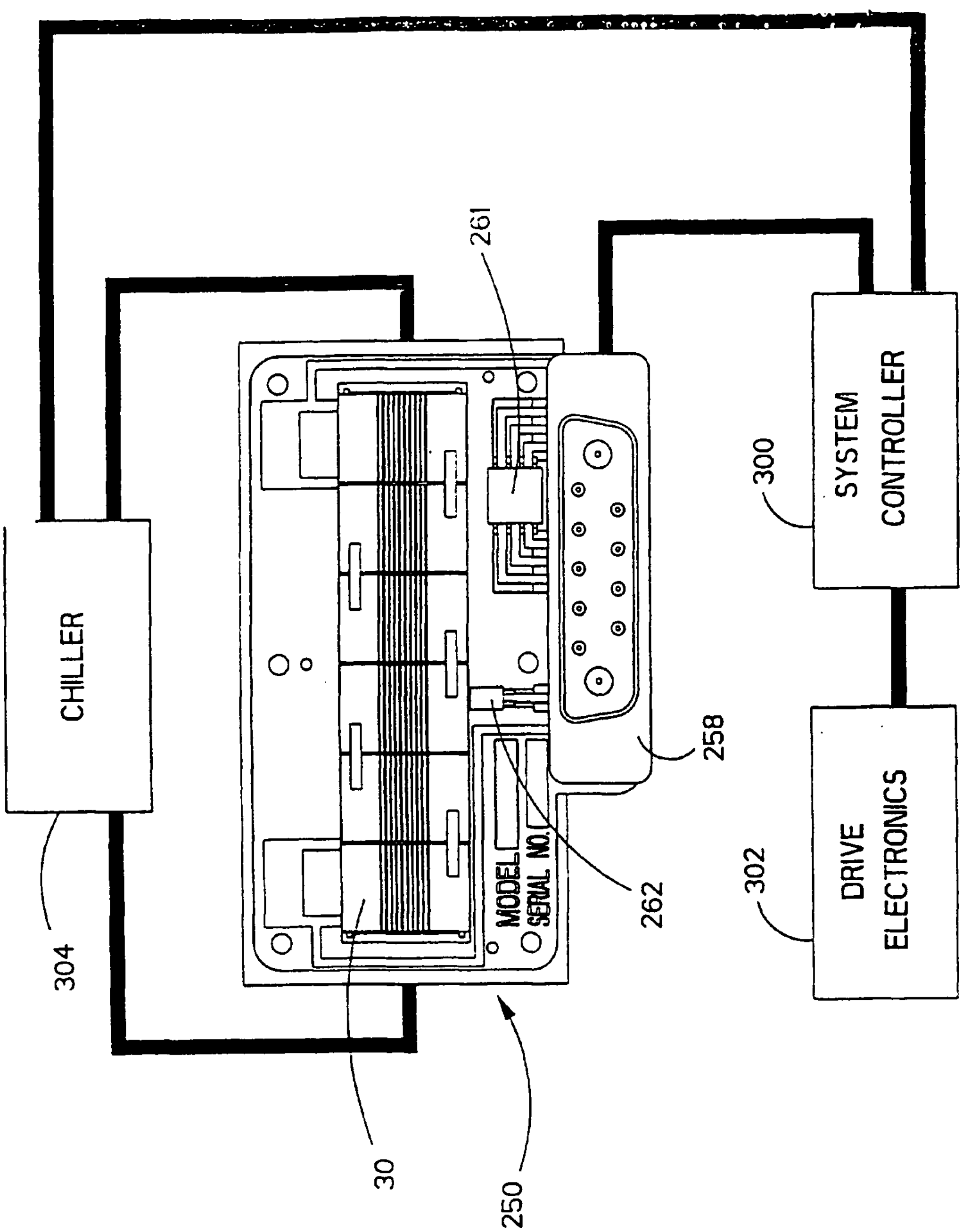


FIGURE 8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304
30
250
MODEL
SERIAL NO.
262
261
258
SYSTEM CONTROLLER
300
DRIVE ELECTRONICS
302

FIGURE 9